EXECUTIVE SUMMARY

This report presents an assessment of the risks to human health and the environment potentially attributable to activities at Operable Unit 5 (OU 5) on Hill Air Force Base (Hill AFB), Utah. Hill AFB was placed on the National Priorities List in July 1987, requiring a series of remedial investigations (RI) and feasibility studies (FS). This Baseline Risk Assessment (BRA) has been conducted under the Federal Facilities Agreement (FFA) between U.S. Environmental Protection Agency (EPA) Region VIII, the Utah Department of Environmental Quality (UDEQ), and the U.S. Air Force (USAF). It is one of nine OUs being investigated under the FFA. OU 5 consists of two sites, the U.S. Army Tooele Rail Shop and Bamberger Pond, located on the western boundary of Hill AFB (Figure ES-1).

Bamberger Pond is a storm water runoff holding system consisting of two unlined basins. The Tooele Rail Shop is a multi-building complex that services and repairs railroad engines for the military. The study area at the Tooele Rail Shop has expanded beyond the immediate area to include a former Base housing area, a former wastewater treatment facility, and the off-Base communities of Sunset and Clinton west of Hill AFB.

The BRA is based on field and laboratory work conducted through August 1994. It updates the Draft Baseline Risk Assessment (Radian, 1994b). 1994 supplemental remedial investigations filled previously identified data gaps and completed definition of the nature and extent of soil and groundwater contamination.

BRA Objectives and Methodology

The objectives of this risk assessment are to determine the human health and ecological risks associated with OU 5. To achieve these objectives, the following steps are required: 1) identify and characterize the chemicals of potential concern (COPCs) at the site; 2) conduct an exposure assessment to estimate the magnitude, frequency, duration, and route of possible human and nonhuman exposure to the chemicals of potential concern; 3) assess the toxicity of exposure to chemicals of potential concern; and 4) develop numerical values to characterize the risk of carcinogenic and noncarcinogenic effects in human and nonhuman populations. Separate risk assessments were conducted for the Tooele Rail Shop and Bamberger Pond sites. Combined impacts were also evaluated.

Chemicals of Potential Concern

Table ES-1 lists the chemicals of potential concern (COPCs) that have been identified for both Tooele Rail Shop and Bamberger Pond. COPCs identified for quantitative risk assessment include chemicals that were: 1) positively detected in at least one sample in a given medium; 2) detected at levels significantly elevated above levels of the same chemical in associated blank samples; and 3) detected at levels significantly elevated above naturally-occurring levels of the same chemical. Some chemicals, including certain essential nutrients (such as iron, potassium, calcium, magnesium), were eliminated from the list of COPCs if maximum detected concentrations were lower than conservative, media-specific risk-based screening levels.

Some of the listed COPCs may not be related to activities that have occurred at OU 5. The widespread use of pesticides both on- and off-Base may be responsible for detected concentrations of these chemicals at OU 5. Some pesticides detected at OU 5 do not occur at the site at levels significantly above levels that occur elsewhere from common land management and agricultural practices. Table ES-2 shows a comparison of concentrations of pesticides and PCBs detected at OU 5, concentrations detected at other OUs at Hill AFB, and concentrations detected in the environment nationwide. In almost every case, concentrations of pesticides and PCBs at OU 5 are lower than, or the same order of magnitude as, concentrations detected at other OUs and elsewhere in the United States. These data are presented for comparison purposes only. They were not used to identify or eliminate chemicals of potential concern.

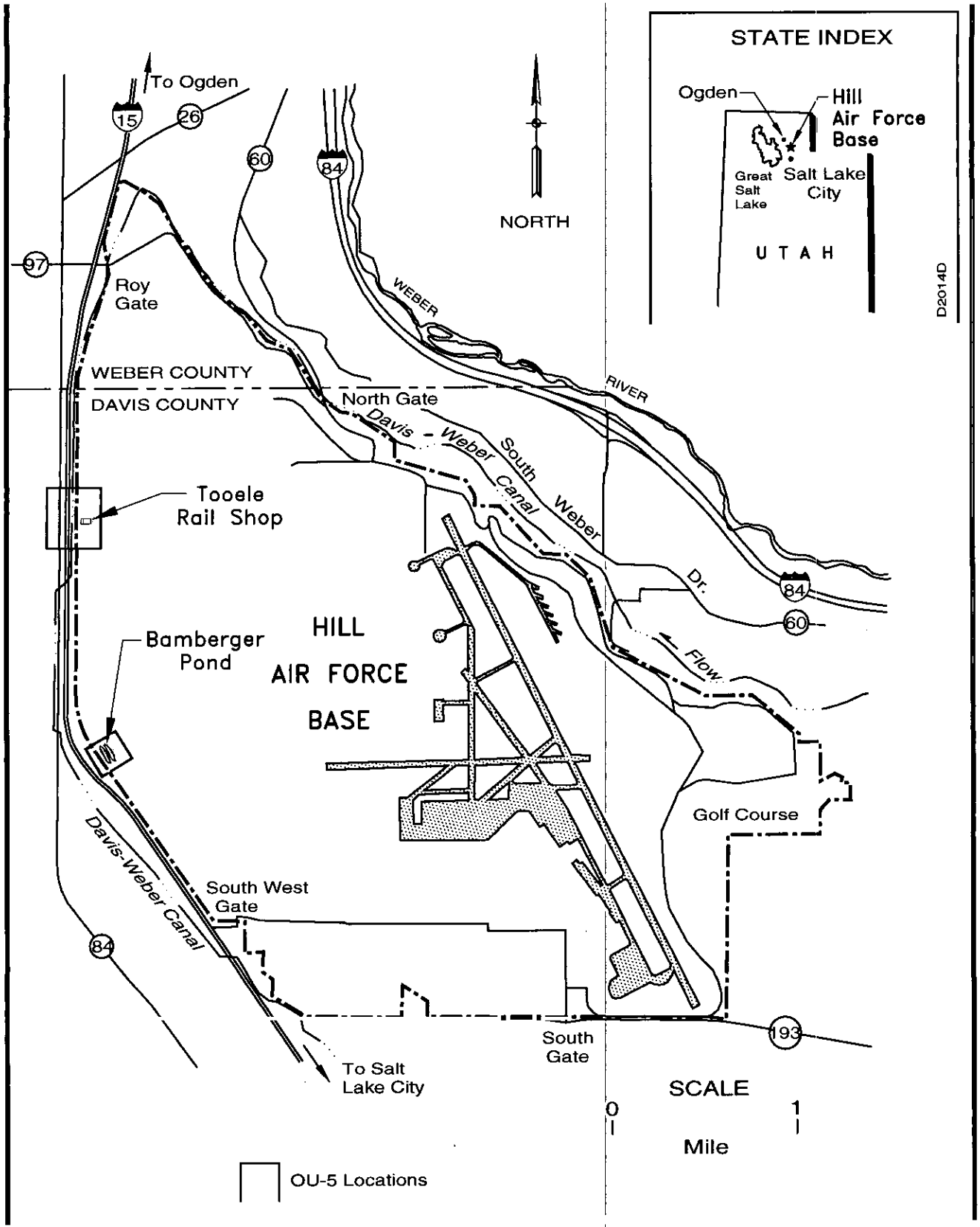


Figure ES-1. Location of Operable Unit 5 Sites (Bamberger Pond and Tooele Rail Shop) at Hill AFB, Utah

Table ES-1
Summary of Chemicals of Potential Concern

Chemical	Tooele Rail Shop			Bamberger Pond			
	Surface Soil	Subsurface Soil	Ground-water	Surface Soil	Subsurface Soil	Sediment	Ground-water
Organics							
Aldrin	X[a]		X[a]				
Benzene			X				X
Benzo(b)fluoranthene	X[a]						
Benzo(k)fluoranthene			X[b]				
alpha-BHC	X[a]		X[b]				X
gamma-BHC	X[a]		X				
Bromodichloromethane			X[d]				
Carbon tetrachloride			X[b,d]				
Chloroform			X				X
Chloromethane			X				
4,4'-DDD			X[b]				
4,4'-DDE	X[a]		X[b]				
4,4'-DDT	X[a]		X[b]				
1,2-Dichloroethane			X				X
1,1-Dichloroethene			X				
Dieldrin	X[a]			X			X
bis(2-Ethylhexyl)phthalate	X[a]		X			X	X
Heptachlor	X[a]		X				
Heptachlor epoxide	X[a]		X				X
Hydrocarbons[c]	X[a]	X[a]					
Indeno(1,2,3-cd)pyrene			X				
2-Methylnaphthalene[c]	X[a]						
PCB-1242			X[a]				
PCB-1260	X			X			
Pentachlorophenol							X
Tetrachloroethene			X[b,d]				
1,1,1-Trichloroethane			X[b]				
1,1,2-Trichloroethane			X[b,d]				
Trichloroethene			X				X
Vinyl chloride			X[d]				

Table ES-1
(Continued)

Chemical	Tooele Rail Shop			Bamberger Pond			
	Surface Soil	Subsurface Soil	Ground-water	Surface Soil	Subsurface Soil	Sediment	Ground-water
Inorganics							
Arsenic	X[a]	X[b]	X[b]	X	X		X
Beryllium	X	X	X[b]				
Cadmium	X[a]		X				
Copper[c]	X[a]						
Fluoride			X				
Lead	X[a]						X
Manganese	X		X[a]				X

[a] Chemical of potential concern in on-Base samples only.
[b] Chemical of potential concern in off-Base samples only.
[c] Retained as a COPC for qualitative evaluation only. Toxicity values are not available to perform risk quantification at this time.
[d] Detected at a frequency <5 percent. Retained as a COPC because it is potentially related to known or suspected contaminant sources. Risks are quantified separately from the more frequently detected COPCs.

Table ES-2
Comparison of Concentrations of Pesticides and PCBs Detected at OU 5 with Concentrations Detected in the Environment Nationwide

Pesticide/PCB	Detection Frequency	Concentrations Detected at OU 5		Concentrations Detected at Other Hill AFB OUs [3]	Levels Detected in the Environment Nationwide [4]	Comment
		Mean	UCL [2]			
Tooele Rail Shop: On-Base Groundwater (µg/L)						
Aldrin	1/11	0.0053	0.0078	0.02-0.1	0.0052-21	Range in detected concentrations in 16 states as reported in EPA's Pesticides in Groundwater database (EPA, 1992g).
gamma-BHC	5/11	0.0064	0.0075	0.11-0.75	0.0006-180	Range in detected concentrations in 22 states as reported in EPA's Pesticides in Groundwater database (EPA, 1992g).
Heptachlor	1/11	0.0048	0.0060	0.01-0.14	0.001-0.8	Range in detected concentrations in 17 states as reported in EPA's Pesticides in Groundwater database (EPA, 1992g).
Heptachlor epoxide	1/8	0.0053	0.0070	0.03-1.5	trace-0.22	Range in detected concentartions in 17 states as reported in EPA's Pesticides in Groundwater database (EPA, 1992g).
PCB-1242	1/14	0.066	0.11	--	--	No data reported.
Tooele Rail Shop: Off-Base Groundwater (µg/L)						
alpha-BHC	2/17	0.0031	0.004	0.016-01	--	No data reported.
gamma-BHC	3/16	0.0052	0.0068	0.11-0.75	0.0006-180	Range in detected concentrations in 22 states as reported in EPA's Pesticides in Groundwater database (EPA, 1992g).
4,4'-DDD	3/18	0.0093	0.016	--	0.0033-1	Range in detected concentrations in 4 states as reported in EPA's Pesticides in Groundwater database (EPA, 1992g).
4,4'-DDE	2/18	0.0072	0.013	--	0.001-0.54	Range in detected concentrations in 6 states as reported in EPA's Pesticides in Groundwater database (EPA, 1992g).
4,4'-DDT	2/16	0.011	0.017	0.06	0.001-3.3	Range in detected concentrations in 6 states as reported in EPA's Pesticides in Groundwater database (EPA, 1992g).
Heptachlor	3/15	0.0062	0.0098	0.01-0.14	0.001-0.8	Range in detected concentrations in 17 states as reported in EPA's Pesticides in Groundwater database (EPA, 1992g).
Heptachlor epoxide	1/13	0.0032	0.0041	0.03-1.5	trace-0.22	Range in detected concentrations in 17 states as reported in EPA's Pesticides in Groundwater database (EPA, 1992g).
Tooele Rail Shop: On-Base Surface Soil (µg/kg)						
Aldrin	2/11	16	36	2.3-20	10-13,300	Range in detected concentrations in cropland soils in 37 states (Carey et al, 1979).
alpha-BHC	1/11	2.4	5.1	1.6-7	10	Concentration of gamma-BHC detected in 9.52% of Alabama soil samples.
gamma-BHC	1/11	32	85	0.6-0.7	10	Concentration of gamma-BHC detected in 9.52% of Alabama soil samples.
4,4'-DDE	7/11	85	240	0.5-540	10-7,160	Range in detected concentrations in cropland soils in 37 states (Carey et al, 1979).

Table ES-2
(Continued)

Pesticide/PCB	Detection Frequency	Concentrations Detected at OU 5		Concentrations Detected at Other Hill AFB OUs[b]	Levels Detected in the Environment Nationwide[c]	Comment
		Mean	UCL[a]			
Dieldrin	4/11	17	37	0.2-10	10-6,180	Range in detected concentrations in cropland soils in 37 states (Carey et al, 1979).
Heptachlor	1/11	4.3	9.5	0.7-30	10-600	Range in detected concentrations in cropland soils in 37 states (Carey et al, 1979).
Heptachlor epoxide	5/11	15	26	7-700	10-720	Range in detected concentrations in cropland soils in 37 states (Carey et al, 1979).
PCB-1260	4/22	29	49	20-7000	10-40	Range in mean concentrations from a comprehensive national soil monitoring program.
Tooele Rail Shop: Off-Base Surface Soil (µg/kg)						
PCB-1260	1/3	8.7	13	20-7000	10-40	Range in mean concentrations from a comprehensive national soil monitoring program.
Bamberger Pond: On-Base Groundwater (µg/L)						
alpha-BHC	*2/5*	*0.0061*	*0.011*	*0.003-0.02*	–	*No data reported.*
Dieldrin	1/5	0.0026	0.0046	0.01-0.04	0-2.6	Range in detected concentrations in 16 states as reported in EPA's Pesticides in Groundwater database (EPA, 1992g).
Heptachlor epoxide	2/5	0.0038	0.0074	0.02-0.3	trace-0.22	Range in detected concentrations in 17 states as reported in EPA's Pesticides in Groundwater database (EPA, 1992g).
Pentachlorophenol	*1/19*	*1.9*	3.5	–	*0.001-0.64*	Range in detected concentrations in 4 states as reported in EPA's Pesticides in Groundwater database (EPA, 1992g).
Bamberger Pond: On-Base Surface Soil (µg/kg)						
Dieldrin	2/6	1.4	3.5	0.2-10	10-6,180	Range in detected concentrations in cropland soils in 37 states (Carey et al, 1979).
PCB-1260	3/6	58	120	20-7000	10-40	Range in mean concentrations from a comprehensive national soil monitoring program.

[a] 95% Upper confidence limit.
[b] From data reported in baseline risk assessment and remedial investigation reports for OU 1, OU 2, and OU 6.
[c] From ATSDR Toxicological Profiles, unless otherwise noted.

Potentially Exposed Populations

Human exposure to contaminants originating at the two sites may occur: 1) in areas close to and downwind of the Tooele Rail Shop and Bamberger Pond via inhalation of the ambient air; 2) in homes located downgradient of the sites that may use the shallow groundwater in the future for drinking water, bathing, cooking, washing clothes, and/or currently or in the future for irrigation of home-grown vegetables and fruits; and 3) in homes located at the site if the Base is closed and residential development occurs (without any prior site remediation). Use of the shallow groundwater to irrigate (or subirrigate) feed crops consumed by beef or dairy cows and/or as stock water can also indirectly lead to human exposure of contaminants originating from the sites.

The risk assessment evaluates the following five populations to determine potential exposures and consequent health risks: 1) off-Base residents; 2) students at Sunset Elementary School; 3) on-Base workers; 4) hypothetical future on-Base residents; and 5) hypothetical future on-Base construction workers. Current on-Base residents are not included in the assessment because of their location and distance from the site.

To address the range of exposures that may occur at the present time and in the future, eight exposure scenarios are evaluated for the Tooele Rail Shop and seven for Bamberger Pond. These are:

Chronic Exposure Scenarios (Seven-Year to Lifetime Exposures)

1. Present off-Base residential;
2. Future off-Base residential;
3. Present and Future off-Base recreational;
4. Present and future on-Base worker (assuming no differences in work practices in the future);
5. Future on-Base residential; and
6. Future on-Base recreational.

Subchronic Exposure Scenarios (Two-Week to Seven-Year Exposures)

1. Present and future Sunset Elementary School student (applicable to Tooele Rail Shop only); and
2. Future on-Base construction worker.

Recreational exposure is addressed separately from residential exposure and assumes swimming or wading in contaminated water, seeps, and springs and ingestion of fish from a fish pond in Clearfield.

Summary of Findings

Human Health Evaluation—Table ES-3 summarizes (by subpopulation) the carcinogenic risks for the exposure scenarios at Tooele Rail Shop and Bamberger Pond. At the Tooele Rail Shop, both average and reasonable maximum risk estimates for the Sunset School student are below the Superfund site remediation threshold for cancer risk of 10^{-6} (1 in one million). Other scenarios below this risk threshold are: 1) Present/Future On-Base Worker, average; 2) Future On-Base Recreational, adult, average; and 3) Future On-Base Construction Worker, average. Estimated risk lower than 10^{-6} are considered "acceptable" and do not warrant remedial action.

Estimated risks for most of the remaining scenarios equal or exceed the risk threshold of 1 in one million, but are within the Superfund site remediation risk range goal of 10^{-6} (1 in one million) to 10^{-4} (1 in 10,000). The adult and age-adjusted reasonable maximum estimates for three scenarios, the Present Off-Base Residential, the Future Off-Base Residential, and the Future On-Base Residential scenarios, exceed the high end of the Superfund risk range goal (10^{-4}).

Arsenic and indeno(1,2,3-cd)pyrene contribute the majority of the risk for the Present Off-Base Residential scenarios, via ingestion of milk and meat from cows supplied with the shallow groundwater as stock water. Trichloroethene and 1,1-dichloroethene in groundwater are the highest contributors to estimated risks for the future Off-Base Residential scenarios via domestic use of the shallow groundwater (drinking and showering). These same chemicals also contribute to

Table ES-3
Summary of Carcinogenic Risks[a] by Exposure Scenario for Tooele Rail Shop and Bamberger Pond, Hill AFB, Utah

Scenario	Age-Adjusted[b]		Adult	
	Average	Reasonable Maximum	Average	Reasonable Maximum
Tooele Rail Shop				
Present Off-Base Residential	**3E-5**	**2E-4**	**1E-5**	**2E-4**
Future Off-Base Residential	**2E-4**	**7E-4**	**8E-5**	**7E-4**
Present/Future Off-Base Recreational	**3E-5**	**8E-5**	**4E-6**	**6E-5**
Present/Future On-Base Worker	NA	NA	4E-7	**8E-6**
Future On-Base Residential	**1E-4**	**6E-4**	**5E-5**	**5E-4**
Future On-Base Recreational	**3E-6**	**8E-6**	5E-7	**7E-6**
Present/Future Sunset School Student	9E-8	6E-7	NA	NA
Future On-Base Construction Worker	NA	NA	4E-7	**6E-6**
Bamberger Pond				
Present Off-Base Residential	**9E-5**	**5E-4**	**3E-5**	**4E-4**
Future Off-Base Residential	**1E-3**	**3E-3**	**4E-5**	**2E-3**
Present Off-Base Recreational	**2E-5**	**6E-5**	**3E-6**	**4E-5**
Future Off-Base Recreational	**2E-5**	**6E-5**	**3E-6**	**4E-5**
Present/Future On-Base Worker	NA	NA	1E-7	**2E-6**
Future On-Base Residential	**1E-3**	**3E-3**	**5E-4**	**3E-3**
Future On-Base Recreational	**3E-5**	**6E-5**	**3E-6**	**4E-5**
Future On-Base Construction Worker	NA	NA	2E-7	**2E-6**

Note: Risk estimates printed in bold type equal or exceed the Superfund site remediation threshold of 10^{-6} (1 in one million) for carcinogens.

NA - Not applicable.

[a] Carcinogenic risk is expressed as a unitless probability of an individual developing cancer.

[b] For residential and recreational exposure scenarios, risks were estimated for an individual whose exposure begins at birth and extends for nine years (average case) or 30 years (reasonable maximum case).

estimated risks for the Off-Base Recreational scenarios, via dermal contact with groundwater while swimming (assuming the groundwater is used to fill a swimming pool).

On Base, ingestion of fruit and vegetables grown in soils containing arsenic and several pesticides (primarily heptachlor epoxide, dieldrin, gamma-BHC, and aldrin) and ingestion of meat and milk from cows supplied with shallow groundwater contaminated with arsenic and indeno(1,2,3-cd)pyrene, contribute the majority of the risk for the residential scenarios. Estimated risks for the On-Base Worker and Construction Worker scenarios are driven by dermal contact with, and ingestion of, soil containing aldrin and arsenic.

At Bamberger Pond, estimated risks for all scenarios, except the Present On-Base Worker (average) and the Future On-Base Construction Worker (average), exceed the Superfund risk threshold of 10^{-6}. Several scenarios exceed the upper end of the risk range goal (10^{-4}). Arsenic dominates the estimated risks for all scenarios. Arsenic in shallow groundwater contributes 97-100% of the estimated risk for the residential and recreational scenarios. Note that arsenic concentrations in groundwater at off-Base locations are estimated concentrations based on groundwater modeling and are not measured concentrations. Arsenic in the soil contributes 68-82% of the estimated risk for the Present On-Base Worker scenario and 85-91% of the estimated risk for the Future On-Base Construction Worker scenario.

Table ES-4 lists all chemicals and pathways that contribute a chemical- and pathway-specific risk greater than the Superfund site remediation risk threshold of 1 in one million. Off Base at Tooele Rail Shop, the majority of these chemicals/pathways are related to volatile organic compounds (VOCs), semi-volatile organic compounds (SVOCs), arsenic, beryllium, and 4,4'-DDT detected in the groundwater. On Base, VOCs, SVOCs, pesticides, and PCBs detected in the groundwater and arsenic, beryllium, pesticides, and PCBs detected in the soil contribute chemical/pathway risks greater than 1 in one million. At Bamberger Pond, arsenic, pentachlorophenol, chloroform, and 1,2-dichloroethane in the groundwater and arsenic, dieldrin, and PCBs in the soil contribute to risks greater than 1 in one million.

Figure ES-2 illustrates the chemical-specific and pathway-specific cancer risks for the Tooele Rail Shop and Bamberger Pond scenarios with the highest estimated risks.

Table ES-5 summarizes (by subpopulation) the noncarcinogenic risks for the exposure scenarios evaluated for Tooele Rail Shop and Bamberger Pond. The hazard indices (HI) for some cases in several scenarios equal or exceed the Superfund site remediation goal of 1 for noncarcinogens. These include the Present and Future Off-Base and Future On-Base Residential scenarios at both sites.

Table ES-6 lists all chemicals and pathways that contribute a chemical- and pathway-specific hazard quotient equal to or greater than 0.5. Off Base at Tooele Rail Shop, all of these chemicals/pathways are related to inorganic chemicals (primarily cadmium and arsenic) detected in the groundwater. On Base, manganese and bis(2-ethylhexyl)phthalate detected in the groundwater and cadmium, arsenic, and pesticides (heptachlor epoxide and aldrin) detected in the soil contribute a chemical/pathway hazard quotient greater than 0.5. At Bamberger Pond, arsenic and manganese in the groundwater contribute a hazard quotient greater than 0.5. Soil-related pathways do not contribute significantly to noncarcinogenic risks at the Bamberger Pond site.

Figure ES-3 illustrates the chemical-specific and pathway-specific noncancer risks for the Tooele Rail Shop and Bamberger Pond scenarios with the highest estimated hazard indices.

At the Tooele Rail Shop site, several chemicals that were infrequently detected in the groundwater at on-Base and/or off-Base locations were evaluated separately from the more frequently detected chemicals of potential concern. Carcinogenic risk estimates for these chemicals exceed 1 in one million for most scenarios, but do not exceed 1 in 10,000. On Base, use of shallow groundwater containing vinyl chloride and 1,1-dichloroethene for domestic purposes (drinking, showering) drive the carcinogenic risk

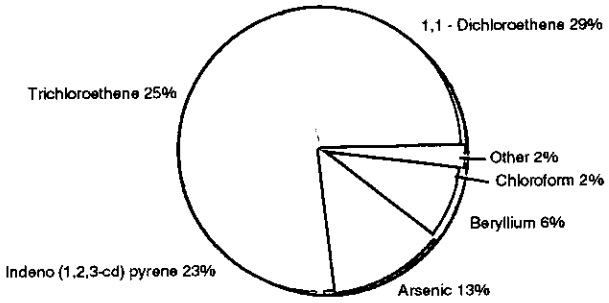
Table ES-4
Chemicals and Pathways that Contribute Cancer Risks Greater than 1 in One Million

Off Base	On Base
Tooele Rail Shop: Groundwater Pathways	
1,1-Dichloroethene - ingestion of shallow groundwater as drinking water - dermal contact with shallow groundwater used for showering/bathing - inhalation of vapors while showering - dermal contact with shallow groundwater used to fill a swimming pool **Trichloroethene** - ingestion of shallow groundwater as drinking water - dermal contact with shallow groundwater used for showering/bathing - inhalation of vapors while showering - inhalation of basement air - dermal contact with shallow groundwater used to fill a swimming pool **Indeno(1,2,3-cd)pyrene** - ingestion of meat and milk from cows supplied shallow groundwater as stock water - ingestion of shallow groundwater as drinking water **Arsenic** - ingestion of shallow groundwater as drinking water - dermal contact with shallow groundwater used for showering/bathing - ingestion of vegetables irrigated with shallow groundwater - ingestion of meat and milk from cows supplied shallow groundwater as stock water **Beryllium** - ingestion of shallow groundwater **Chloroform** - inhalation of vapors while showering - inhalation of basement air **bis(2-Ethylhexyl)phthalate** - ingestion of shallow groundwater as drinking water **Chloromethane** - inhalation of vapors while showering	**4,4'-DDT** - dermal contact with shallow groundwater used for showering/bathing **Indeno(1,2,3-cd)pyrene** - ingestion of shallow groundwater as drinking water - ingestion of meat and milk from cows supplied shallow groundwater as stock water **bis(2-Ethylhexyl)phthalate** - ingestion of shallow groundwater as drinking water - ingestion of vegetables irrigated with shallow groundwater **Trichloroethene** - ingestion of shallow groundwater as drinking water - dermal contact with shallow groundwater used for showering/bathing - inhalation of vapors while showering - dermal contact with shallow groundwater used to fill a swimming pool **PCB-1242** - ingestion of shallow groundwater as drinking water **Chloroform** - inhalation of vapors while showering **Chloromethane** - inhalation of vapors while showering **Aldrin** - ingestion of shallow groundwater as drinking water
Tooele Rail Shop: Soil Pathways	
Beryllium - dermal contact with soil at residence - ingestion of soil at residence	**Arsenic** - ingestion of soil at residence and at construction site - dermal contact with soil at residence and at work site - ingestion of fruits and vegetables grown in on-Base soils **Aldrin** - dermal contact with soil at residence, at work site, and at construction site - ingestion of fruits and vegetables grown in on-Base soils

Table ES-4
(Continued)

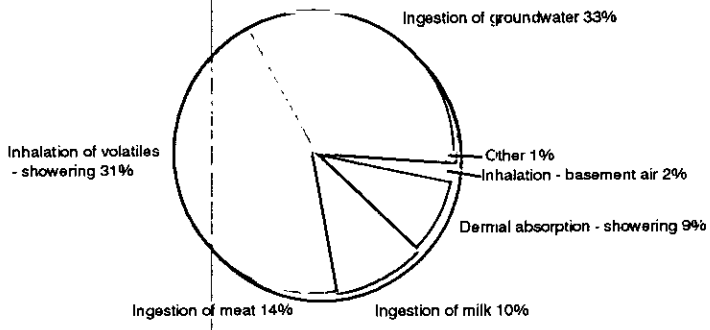
Off Base	On Base
Toole Rail Shop: Soil Pathways (continued)	
	Heptachlor epoxide - dermal contact with soil at residence - ingestion of fruits and vegetables grown in on-Base soils **PCB 1260** - dermal contact with soil at residence - ingestion of fruits and vegetables grown in on-Base soils **gamma-BHC** - ingestion of fruits and vegetables grown in on-Base soils **Dieldrin** - dermal contact with soil at residence - ingestion of fruits and vegetables grown in on-Base soils **Beryllium** - ingestion of vegetables grown in on-Base soils
Bamberger Pond: Groundwater Pathways	
Arsenic - ingestion of shallow groundwater as drinking water - dermal contact with shallow groundwater used for showering/bathing - ingestion of fruits and vegetables irrigated with shallow groundwater - ingestion of meat and milk from cows supplied shallow groundwater as stock water - dermal contact with, and ingestion of, shallow groundwater used to fill a swimming pool **Pentachlorophenol** - ingestion of shallow groundwater as drinking water	**Arsenic** - ingestion of shallow groundwater as drinking water - dermal contact with shallow groundwater used for showering/bathing - ingestion of fruits and vegetables irrigated with shallow groundwater - ingestion of meat and milk from cows supplied shallow groundwater as stock water - dermal contact with and ingestion of, shallow groundwater used to fill a swimming pool **Pentachlorophenol** - ingestion of shallow groundwater as drinking water **Chloroform** - inhalation of vapors while showering **1,2-Dichloroethane** - inhalation of vapors while showering
Bamberger Pond: Soil Pathways	
None	**Arsenic** - ingestion of soil at residence and construction site - dermal contact with soil at residence - ingestion of fruit and vegetables grown in on-Base soils **Dieldrin** - ingestion of vegetables and fruits grown in on-Base soils **PCB-1260** - dermal contact with soil at residence - ingestion of vegetables and fruits grown in on-Base soils

Carcinogenic Risk by Contaminant Contribution
Tooele Rail Shop: Off-Base Residential
Age-Adjusted-Future
(reasonable maximum)



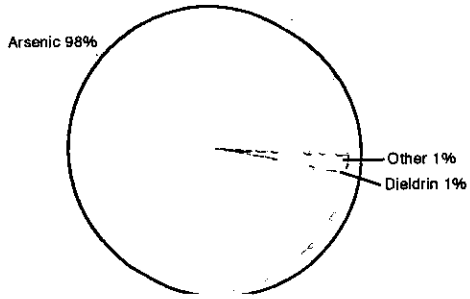
Total Cancer Risk = 7 in 10,000

Carcinogenic Risk by Pathway Contribution
Tooele Rail Shop: Off-Base Residential
Age-Adjusted-Future
(reasonable maximum)



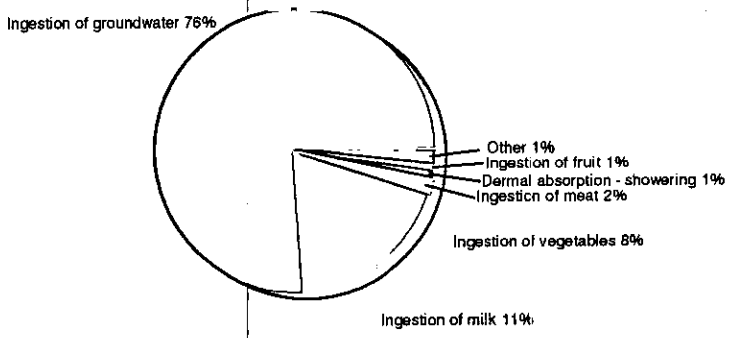
Total Cancer Risk = 7 in 10,000

Carcinogenic Risk by Contaminant Contribution
Bamberger Pond: On-Base Residential
Age-Adjusted-Future
(reasonable maximum)



Total Cancer Risk = 3 in 1,000

Carcinogenic Risk by Pathway Contribution
Bamberger Pond: On-Base Residential
Age-Adjusted-Future
(reasonable maximum)



Total Cancer Risk = 3 in 1,000

Figure ES-2

Chemical- and Pathway-Specific Cancer Risks for Selected Tooele Rail Shop and Bamberger Pond Scenarios

Table ES-5
Summary of Noncarcinogenic Hazard Indices[a] by Exposure Scenario for Tooele Rail Shop and Bamberger Pond, Hill AFB, Utah

Scenario	Child		Adult	
	Average	Reasonable Maximum	Average	Reasonable Maximum
Tooele Rail Shop				
Present Off-Base Residential	**1**	**3**	0.02	0.6
Future Off-Base Residential	**5**	**7**	**1**	**3**
Present/Future Off-Base Recreational	0.1	0.5	0.05	0.2
Present/Future On-Base Worker	NA	NA	0.01	0.09
Future On-Base Residential	**7**	**10**	**2**	**4**
Future On-Base Recreational	0.07	0.3	0.02	0.1
Present/Future Sunset School Student	0.002	0.03	NA	NA
Future On-Base Construction Worker	NA	NA	0.05	0.4
Bamberger Pond				
Present Off-Base Residential	**3**	**6**	0.5	**2**
Future Off-Base Residential	**30**	**30**	**8**	**10**
Present Off-Base Recreational	0.2	0.7	0.04	0.2
Future Off-Base Recreational	0.2	0.7	0.04	0.2
Present/Future On-Base Worker	NA	NA	0.001	0.003
Future On-Base Residential	**30**	**30**	**8**	**10**
Future On-Base Recreational	0.2	0.7	0.04	0.2
Future On-Base Construction Worker	NA	NA	0.02	0.1

Note: Hazard indices printed in bold type equal or exceed the Superfund site remediation goal of 1 for noncarcinogens.

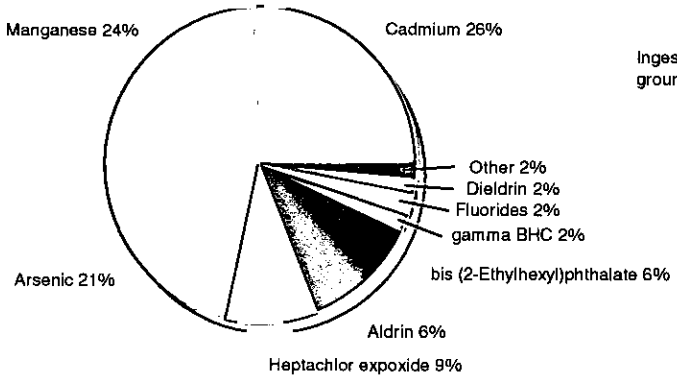
NA - Not applicable.

[a] Noncarcinogenic risk is not expressed as a probability of an adverse effect but rather a comparison between exposure and a reference dose (Hazard Index).

Table ES-6
Chemicals and Pathways that Contribute a Noncancer Hazard Quotient Greater than 0.5

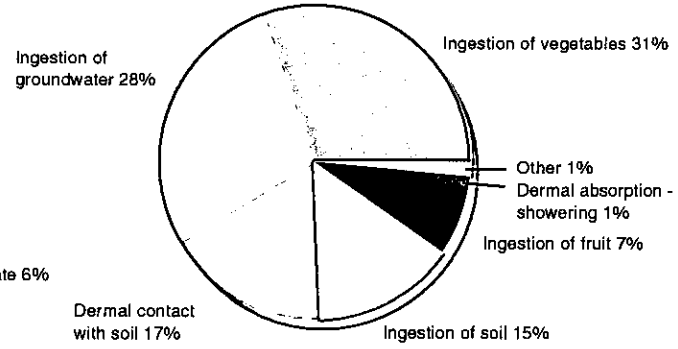
Off-Base	On-Base
Tooele Rail Shop: Groundwater Pathways	
Cadmium - ingestion of shallow groundwater used as drinking water - ingestion of vegetables irrigated with shallow groundwater **Arsenic** - ingestion of shallow groundwater used as drinking water **Fluorides** - ingestion of shallow groundwater used as drinking water	**Manganese** - ingestion of shallow groundwater used as drinking water **bis(2-Ethylhexyl)phthalate** - ingestion of shallow groundwater used as drinking water
Tooele Rail Shop: Soil Pathways	
None	**Cadmium** - ingestion of soil at residence - dermal contact with soil at residence - ingestion of vegetables grown in on-Base soils **Arsenic** - ingestion of vegetables grown in on-Base soils **Aldrin** - dermal contact with soil at residence **Heptachlor epoxide** - ingestion of vegetables and fruits grown in on-Base soils
Bamberger Pond: Groundwater Pathways	
Arsenic - ingestion of shallow groundwater as drinking water - ingestion of vegetables irrigated with shallow groundwater - ingestion of milk from cows supplied with shallow groundwater as stock water **Manganese** - ingestion of shallow groundwater used as drinking water	**Arsenic** - ingestion of shallow groundwater as drinking water - ingestion of vegetables and fruit irrigated with shallow groundwater - ingestion of milk from cows supplied with shallow groundwater as stock water. **Manganese** - ingestion of shallow groundwater used as drinking water
Bamberger Pond: Soil Pathways	
None	None

Noncarcinogenic Risk by Contaminant Contribution
Tooele Rail Shop: On-Base Residential Child-Future
(reasonable maximum)



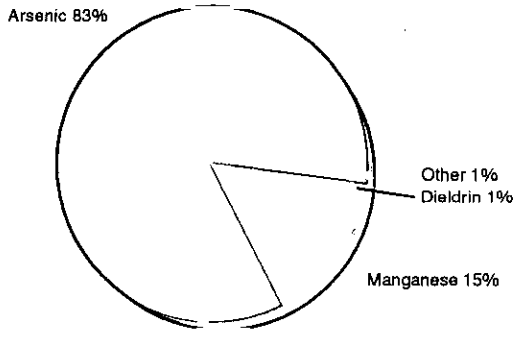
Total Hazard Index = 10

Noncarcinogenic Risk by Pathway Contribution
Tooele Rail Shop: On-Base Residential Child-Future
(reasonable maximum)



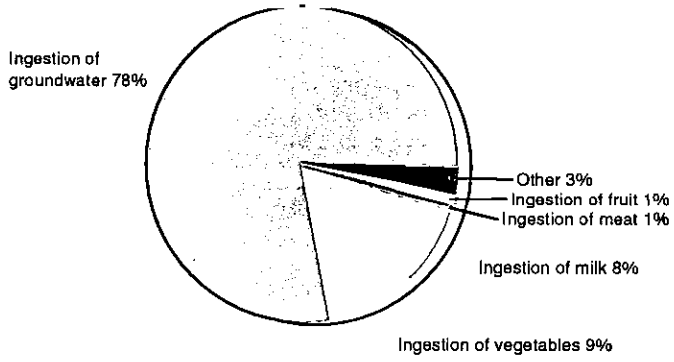
Total Hazard Index = 10

Noncarcinogenic Risk by Contaminant Contribution
Bamberger Pond: On-Base Residential Child-Future
(reasonable maximum)



Total Hazard Index = 30

Noncarcinogenic Risk by Pathway Contribution
Bamberger Pond: On-Base Residential Child-Future
(reasonable maximum)



Total Hazard Index = 30

Figure ES-3
Chemical- and Pathway-Specific Noncancer Risks for Selected Tooele Rail Shop and Bamberger Pond Scenarios

estimates. Off Base, inhalation of vinyl chloride in basement air, and use of shallow groundwater containing vinyl chloride in the home for drinking and showering, contribute the majority of the estimated risk. Noncarcinogenic hazard indices associated with the infrequently detected chemicals are lower than 1 for all scenarios.

Environmental Evaluation—The qualitative evaluation of potential adverse impacts of contamination from OU 5 on critical habitats and endangered species in the area indicates that deleterious effects from the site contaminants are not likely. Impacts on the wetlands bordering the Great Salt Lake are also not likely. Since seeps and springs are generally upgradient of wetlands bordering the Great Salt Lake, contaminant concentrations will be higher in seeps and springs closer to the Base than concentrations potentially migrating to the wetlands. Concentrations observed in the seeps and springs are generally 3-4 orders of magnitude lower than acute or chronic water quality criteria for freshwater aquatic life. Concentrations at the wetlands further downgradient, if the wetlands receive shallow groundwater migrating from OU 5, would be even lower due to further dilution and volatilization.

Interpretation of Results

Uncertainty is inherent to the risk assessment process. To resolve uncertainty, sometimes conservative assumptions are made which lead to overestimates of the risks. Gathering additional data will not always resolve or reduce uncertainty. At OU 5, the greatest source of uncertainty is 1) the inclusion of chemicals in the assessment that may not be attributable to site-related activities, and 2) the oral carcinogenity of arsenic. These and other uncertainties should be considered when risk management decisions are made based on the cancer and noncancer risk estimates.

The slope factor used to estimate cancer risk from ingestion of arsenic is controversial. It is a proposed value that is subject to change in the near future pending the outcome of further review now being conducted by EPA (IRIS-arsenic). Some studies suggest that the current oral slope factor for arsenic may overestimate risks by an order of magnitude or two (Risk Policy Report, 1994). Ongoing and newly funded research will serve to fill in data gaps that make existing information unsuitable for assessing cancer risks from low exposures to arsenic.

There is also some uncertainty regarding whether or not some naturally-occurring elements (primarily arsenic, cadmium, manganese, and beryllium) exist at the site at levels exceeding background concentrations. The ability to determine a statistically significant difference between site and background concentrations depends to a certain extent on the size of the background data set. Since there is no historical evidence of activities at OU 5 that might have contributed these inorganic chemicals to the soils and groundwater, it is possible that concentrations of these elements detected at the site are not elevated above naturally-occurring levels.

For example, although site-specific background comparisons conclude that arsenic concentrations in some soils and groundwater at the Tooele Rail Shop and Bamberger Pond are elevated above site-specific background, the original source that potentially contributed arsenic to the sites has not been identified. Arsenic may be naturally-occurring, and a specific source may not be identifiable. Most natural soils contain low levels of arsenic. Background arsenic concentrations in soil ranges from 1 to 40 mg/kg; soils overlying arsenic-rich geological deposits such as sulfide ores may have soil concentrations two orders of magnitude higher (ATSDR-arsenic). Arsenic concentrations in soils in the Salt Lake City area range from 6.5 to 100 mg/kg (Shacklette and Boerngen, 1984). At the Bamberger Pond site, measured arsenic concentrations ranged from 4 to 8 mg/kg in surface soil and from 0.85 to 13 mg/kg in subsurface soil. At the Tooele Rail Shop, concentrations ranged from 3 to 68 mg/kg in surface soils and from 0.7 to 14 mg/kg in subsurface soil. Typically arsenic (about 80% of the total) that is released to the environment from human activities is released to soil (ATSDR-arsenic). Application of pesticides and disposal of solid wastes from fossil fuel combustion and industrial processes are the major sources (ATSDR-arsenic). The latter has not occurred at OU 5; the former has occurred basewide, but is not unique to OU 5.

Arsenic is also widely distributed in surface water, groundwater, and finished drinking water in the United States. Arsenic levels in groundwater average about 1 to 2 μg/L, except in some western states with volcanic rock and sulfide mineral deposits high in arsenic, where arsenic levels up to 3,400 μg/L have been observed (ATSDR-arsenic). In western mining areas, groundwater arsenic concentrations up to 48,000 μg/L have been reported (ATSDR-arsenic). At Tooele Rail Shop, measured concentrations of arsenic in groundwater ranged from 0.7 to 15 μg/L. At the Bamberger Pond site, concentrations in groundwater ranged from 18 to 215 μg/L. At the Bamberger site, it is possible that elevated concentrations in groundwater occur as a result of leaching and surface runoff from the soils to the pond, and subsequent migration from the pond to shallow groundwater. It is not known if concentrations in the soil are naturally-occurring or result from some activity, such as general pesticide application.

Table ES-7 summarizes the statistical evidence that concentrations of the inorganic chemicals that contribute significantly to estimated risks at the site exceed site-specific background concentrations. The table provides the site and background 95% Upper Confidence Limits (UCLs) of the mean, the ratio of the background UCL and the site UCL, the statistical test type employed, resulting p-value, and a qualitative measure of the level of confidence in the conclusion (that site concentrations exceed background concentrations). The level of confidence is moderate that site-related arsenic concentrations exceed background concentrations in groundwater at off-Base locations at the Tooele Rail Shop, in on-Base surface soil at Tooele Rail Shop, and in groundwater at Bamberger Pond. The level of confidence is also moderate that site-related concentrations of cadmium in Tooele Rail Shop on-Base surface soil exceed background. However, the level of confidence is weak for the other inorganic chemical risk drivers.

Table ES-8 presents a comparison of the estimated chemical-specific risks for site and background concentrations of the inorganic risk drivers. The comparison is based on estimated risk for the Future Residential (age-adjusted or child) scenario. The comparison demonstrates that, in most cases, the estimated cancer and noncancer risk of exposure to background concentrations of these inorganic chemicals is almost as high as exposure to concentrations detected at the site. Estimated cancer risks associated with exposure to background concentrations of these inorganic chemicals exceed the 1 in one million Superfund cancer risk threshold. Estimated noncancer hazard indices associated with exposure to background concentrations also exceed one, the Superfund site remediation goal for noncarcinogens, for many of these chemicals.

There is also uncertainty about pesticides and PCBs detected at OU 5 and a correlation in whole or in part to site-related activities. Soil and groundwater background samples from OU 5 were not analyzed for pesticides and PCBs because background comparisons are generally limited to naturally-occurring chemicals. Detected concentrations of pesticides in the soils and groundwater at OU 5 may be a result of historical application of pesticides both on Base and off Base. In some cases, off-Base concentrations of pesticides greatly exceed concentrations detected on Base. All or part of the concentrations detected off Base may originate from sources other than OU 5.

Polycyclic aromatic hydrocarbons (PAHs) also are wide-spread in the environment. It is not certain that PAHs detected at the Tooele Rail Shop and Bamberger Pond sites were contributed by site-related activities.

Inhalation of basement air containing chloroform contributes to estimated risks in excess of 1 in one million for the residential exposure scenarios (at the Tooele Rail Shop site only). However, concentrations of chloroform detected in the basement air at locations within the area of the OU 5 groundwater plume were not elevated above concentrations detected at three locations outside of the plume area. Many sources, in addition to contaminated shallow groundwater, can contribute chloroform to indoor air. Indeed, concentrations of chloroform in all basements sampled west of OU 5 were nearly always below the nationwide background mean for chloroform in indoor air from a study conducted by Shah and Singh (1988).

Table ES-7
Summary of Background Comparison for Inorganic Risk Drivers

Chemical	Site UCL[a]	Background UCL[a]	Ratio of Background UCL to Site UCL	Background Comparison		
				Test Type	p-Value	Level of Confidence[b]
Tooele Rail Shop On-Base Groundwater (mg/L)						
Cadmium	0.0008	0.0004	0.5	Unequal Var L	0.086	Weak
Manganese	0.20	0.24	1.2	Wilcoxon	0.18	Weak
Tooele Rail Shop Off-Base Groundwater (mg/L)						
Arsenic	0.0033	0.0014	0.42	Wilcoxon	0.021	Moderate
Beryllium	0.0006	0.0007	1.2	Wilcoxon	0.16	Weak
Cadmium	0.0004	0.0004	1	Wilcoxon	0.047	Moderate
Tooele Rail Shop On-Base Surface Soil (mg/kg)						
Arsenic	13	4.6	0.35	Wilcoxon	0.045	Moderate
Cadmium	1.0	0.25	0.25	Wilcoxon	0.046	Moderate
Beryllium	0.31	0.30	0.96	Wilcoxon	0.078	Weak
Tooele Rail Shop Off-Base Surface Soil (mg/kg)						
Beryllium	0.41	0.30	0.73	Equal Var t-t	0.14	Weak
Bamberger Pond Groundwater (mg/L)						
Arsenic	0.098	0.0014	0.014	Wilcoxon	0.017	Moderate
Manganese	0.36	0.24	0.67	Wilcoxon	0.09	Weak
Bamberger Pond Surface Soil (mg/kg)						
Arsenic	6.8	4.6	0.68	Wilcoxon	0.16	Weak

[a] 95% Upper Confidence Limit of the mean.

[b] Level of confidence rating is a function of the p-value, as follows:

- Strong - p-value <0.01
- Moderate - p-value ≥ 0.01 and <0.05
- Weak - p-value ≥ 0.05 and <0.2
- Little - p-value ≥ 0.2

Table ES-8
Comparison of Estimated Risks for Site and Background Concentrations of Inorganic Risk Drivers

Chemical	Estimated Chemical-Specific Risks for the Future Residential Scenario (Age-Adjusted/Child, Reasonable Maximum)			
	Cancer Risk		Noncancer Hazard Quotient	
	Site	Background	Site	Background
Tooele Rail Shop On-Base Groundwater				
Cadmium	--	--	0.2	0.1
Manganese	--	--	3	4
Tooele Rail Shop Off-Base Groundwater				
Arsenic	9E-5	4E-5	0.9	0.4
Beryllium	3E-5	4E-5	0.008	0.01
Cadmium	--	--	2	2
Tooele Rail Shop On-Base Surface Soil				
Arsenic	2E-4	7E-5	3	1
Beryllium	5E-6	5E-6	0.002	0.002
Cadmium	2E-13	5E-14	3	1
Tooele Rail Shop Off-Base Surface Soil				
Beryllium	4E-6	3E-6	0.002	0.001
Bamberger Pond Groundwater				
Arsenic	3E-3	4E-5	26	0.4
Manganese	--	--	5	3
Bamberger Pond Surface Soil				
Arsenic	2E-5	1E-5	0.3	0.2

Tables ES-9 and ES-10 examine the sensitivity of the carcinogenic and noncarcinogenic risk estimates to inclusion of chemicals that may not be attributable to OU 5. The tables show, for the age-adjusted or child, reasonable maximum case, the effect of excluding pesticides and PCBs, PAHs, several specified inorganic chemicals, and chloroform in the basement air, on the total estimated risk.

For carcinogenic risk (Table ES-9), excluding these chemicals from the risk estimates does significantly reduce the overall risk. A few of the estimates for the age-adjusted, reasonable maximum case that originally exceeded the 1 in one million Superfund site remediation risk threshold fall below the threshold. For the age-adjusted, average and adult average and reasonable maximum cases (not shown in Table ES-9), estimated risks for more scenarios do fall below the 1 in one million threshold.

For noncarcinogenic risk (Table ES-10), however, all of the estimated hazard indices that originally exceeded the Superfund site remediation goal of 1 fall below this threshold when pesticides, PCBs, arsenic, cadmium, manganese, and fluorides are excluded from consideration. Exclusion of arsenic has the most significant potential effect, particularly for Bamberger Pond scenarios.

Of the chemicals that contribute estimated cancer risks in excess of 1 in one million or a noncancer hazard quotient greater than 0.5, only 1,1-di-chloroethene, trichloroethene, chloroform, chloromethane, and bis(2-ethylhexyl)phthalate at the Tooele Rail Shop, and chloroform at Bamberger Pond, are clearly attributable to OU 5. Even so, the estimated risks associated with exposure to these chemicals are still uncertain and may be overstated. For example, the slope factor used to estimate cancer risk from exposure to trichloroethene is an unverified value that was withdrawn from EPA's toxicity value database. It is classified as a Group B2/C carcinogen, which means there is no evidence of carcinogenesis in humans and sufficient (B2) or limited (C) evidence in animal studies. Chloromethane is classified as a Group C carcinogen, and the oral and inhalation slope factors used to estimate risk are highly uncertain and not verified.

Recommendations

The remedial investigation and baseline risk assessment for OU 5 provide sufficient information and analysis to proceed to the feasibility study phase of site investigation/restoration. Based on the results of the baseline risk assessment, Hill AFB, in conjunction with U.S. EPA, Region VIII, and State of Utah DEQ, can identify the chemicals that require remediation and devise clean-up strategies that are protective of public health.

A series of non-time critical removal actions has been proposed to partially address the chemicals of potential concern identified in this document. The extent of the off-Base contaminant plume encourages proceeding to a complete remedial solution as soon as possible.

Two additional small sampling efforts are currently planned to support the evaluation presented in this baseline risk assessment. The results of these efforts will be incorporated into the Feasibility Study Report.

The first sampling effort will involve collecting groundwater from BAT-1A, MW-126, and MW-138. These wells had the greatest concentrations of bis(2-ethylhexyl)phthalate, a fairly ubiquitous plasticizer frequently detected as a laboratory contaminant or introduced by the sampling procedures. It has been considered a contaminant of potential concern in this report, but future data may justify deleting it if it is present in concentrations below risk-based concentrations when the wells are resampled.

The second sampling effort addresses arsenic in the off-Base area downgradient from Bamberger Pond. The maximum groundwater concentration of arsenic measured at Bamberger Pond was 220 μg/L. Concentrations in surface soils were as high as 8.2 mg/kg. Concentrations up to 13 mg/kg were measured in subsurface soils. These concentrations exceed background and risk-based concentrations, so it is considered a contaminant of potential concern. However, additional data on the off-Base risks will enable a more thorough evaluation to be made of alternatives for this site.

Table ES-9
Sensitivity of Carcinogenic Risk Estimates to Inclusion
of Chemicals That May Not Be Attributable to OU 5

Scenario	Carcinogenic Risk (Age-Adjusted, Reasonable Maximum) *				
	Including All Chemicals	Excluding Pesticides, PCBs	Plus Excluding PAHs	Plus Excluding Arsenic	Plus Excluding Chloroform in Basement Air
Tooele Rail Shop					
Present Off-Base Residential	**2E-4**	**1E-4**	**3E-5**	**1E-5**	**3E-6**
Future Off-Base Residential	**7E-4**	**6E-4**	**5E-4**	**4E-4**	**4E-4**
Present/Future Off-Base Recreational	**8E-5**	**7E-5**	**7E-5**	**7E-5**	**7E-5**
Present/Future On-Base Worker [b]	**8E-6**	**2E-6**	**2E-6**	2E-11	2E-11
Future On-Base Residential	**6E-4**	**4E-4**	**2E-4**	**3E-5**	**3E-5**
Future On-Base Recreational	**8E-6**	**3E-6**	**3E-6**	**3E-6**	**3E-6**
Present/Future Sunset School Student	6E-7	E-7	5E-7	0	0
Future On-Site Construction Worker [b]	**6E-6**	**4E-6**	**4E-6**	2E-11	2E-11
Bamberger Pond					
Present Off-Base Residential	**5E-4**	**5E-4**	**5E-4**	5E-12	NA
Future Off-Base Residential	**3E-3**	**0.003**	**3E-3**	**1E-6**	NA
Present Off-Base Recreational	**6E-5**	**6E-5**	**6E-5**	2E-7	NA
Future Off-Base Recreational	**6E-5**	**6E-5**	**6E-5**	2E-7	NA
Present/Future On-Base Worker [b]	**2E-6**	**1E-6**	**1E-6**	0	NA
Future On-Base Residential	**3E-3**	**3E-3**	**3E-3**	**7E-6**	NA
Future On-Base Recreational	**6E-5**	**6E-5**	**6E-5**	9E-7	NA
Future On-Base Construction Worker [b]	**2E-6**	**2E-6**	**2E-6**	0	NA

Note: Carcinogenic risk estimates printed in bold type equal or exceed the Superfund site remediation threshold of 10^{-6} (1 in one million) for carcinogens.

* Except where otherwise noted for the on-Base worker and on-site construction worker scenarios.
[b] Estimates are for the adult, reasonable maximum case.

Table ES-10
Sensitivity of Noncarcinogenic Hazard Indices to Inclusion of Chemicals That May Not Be Attributable to OU 5

Scenario	Noncarcinogenic Hazard Index (Child, Reasonable Maximum) [a]			
	Including All Chemicals	Excluding Pesticides/PCBs	Plus Excluding Arsenic, Cadmium, and Manganese	Plus Excluding Fluorides
Tooele Rail Shop				
Present Off-Base Residential	**3**	**3**	0.02	0.02
Future Off-Base Residential	**7**	**7**	**1**	0.4
Present/Future Off-Base Recreational	**5**	0.3	0.04	0.01
Present/Future On-Base Worker [b]	0.09	0.06	0.0001	0.0001
Future On-Base Residential	**10**	**10**	**1**	0.7
Future On-Base Recreational	0.3	0.3	0.07	0.07
Present/Future Sunset School Student	0.03	0.03	0.0002	0.0002
Future On-Base Construction Worker [b]	0.4	0.2	0.001	0.001
Bamberger Pond				
Present Off-Base Residential	**6**	**6**	4E-08	4E-08
Future Off-Base Residential	**30**	**30**	0.009	0.009
Present Off-Base Recreational	0.7	0.7	0.007	0.007
Future Off-Base Recreational	0.7	0.7	0.007	0.007
Present/Future On-Base Worker [b]	0.003	0.002	0	0
Future On-Base Residential	**30**	**30**	0.04	0.04
Future On-Base Recreational	0.7	0.7	0.02	0.02
Future On-Base Construction Worker [b]	0.1	0.1	0	0

Note: Noncarcinogenic hazard indices printed in bold type equal or exceed the Superfund site remediation goal of 1 in noncarcinogens.

[a] Except where otherwise noted for the on-base worker and on-base construction worker scenarios.
[b] Estimates are for the adult, reasonable maximum case.